



BNL's Role in ATLAS

From Construction to the Installation/Commissioning

Hong Ma

**DOE Annual HEP Review
Brookhaven National Lab
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BNL's Role in ATLAS

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H. Gordon (now on ATLAS EB)

- ◆ Physics
- ◆ BNL Role US ATLAS Management
- ◆ Plans for Analysis Center

- **From Construction to the Installation/Commissioning**
Work in close collaboration with the Instrumentation Division

H. Ma

- ◆ Liquid argon calorimeter
 - Cryostat and Cryogenics
 - LAr Readout
- ◆ Cathode strip chambers for the Muon system
- ◆ Atlas Technical Coordination
- ◆ Atlas upgrade – tracking/calorimeter

- **Software and computing/Transition to Physics**

S. Rajagopalan

- ◆ Software
 - Core, Simulation/Reconstruction
- ◆ Analysis & Physics
- ◆ Facility Support



General Approach

- **BNL construction responsibilities matched to our physics interest and technical expertise.**
- **BNL Physics Dept and Instrumentation Division were pioneers in R&D for both LAr calorimeter and Cathode Strip Chambers.**
- **Focus on overall system, from construction, electronics, detector software to physics performance.**



LAr Cryostat & Cryogenics

- **LAr cryostat/cryogenics**
 - ◆ **Barrel cryostat**
 - ◆ **Signal Feedthroughs**
 - ◆ **LN₂ refrigerator**
 - ◆ **N₂ Dewar**
 - ◆ **Quality meters**
- **Collaboration of Physics Dept, Magnet and Instrumentation Division.**



Barrel Cryostat

- **Persons Responsible:** D. Lissauer , J. Sondericker (Eng.)
- **Institutions:** BNL, University of Rochester
- **Responsibility:** Design and production including final acceptance tests, installation.
- **Designed at BNL, manufactured by KHI in Japan**
- **Production started in March 1999 in KHI**
- **Delivered to CERN in July 2001**
- **Final acceptance by CERN in Sept 2002**
- **Installation to be completed by '05**





Signal Feedthroughs

- **Persons responsible:** B. Hackenburg, T. Muller (Eng.)
- **Institutions:** BNL
- **Responsibility:** All Feedthroughs for Barrel and Endcaps
- **High signal density and fidelity,**
 - ◆ 1920 channels/FT
 - ◆ 64 Feedthrough assemblies
- **Production and Test facility at BNL**
- **Started shipping to CERN in July 2001**
- **Production completed by March 2002**
- **Installation completed on barrel.**



Feedthrough, pedestal, baseplane installed



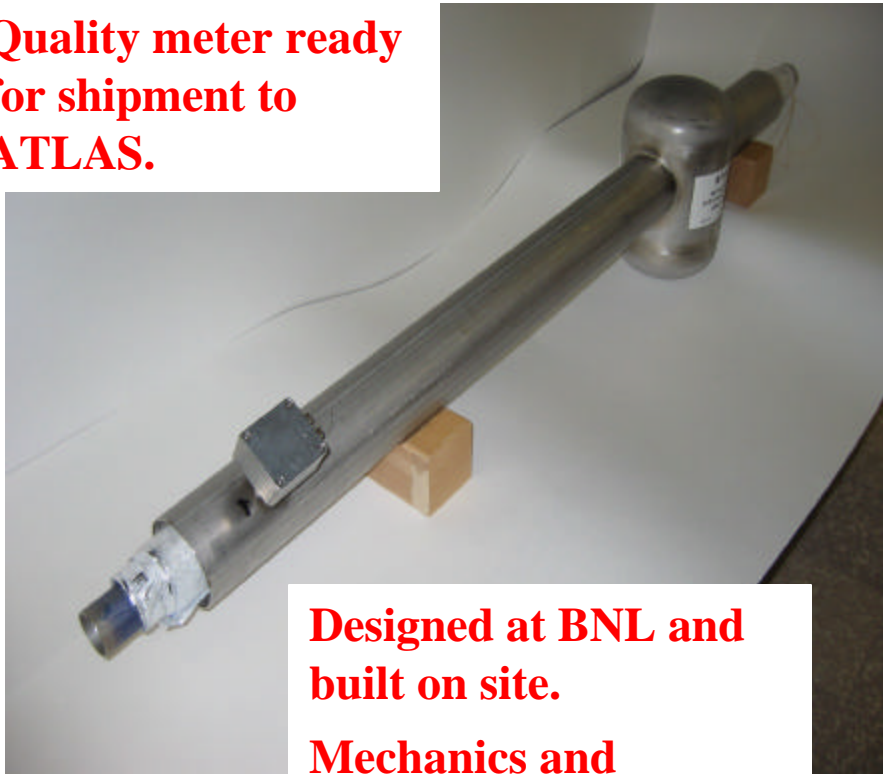
Cryogenics

- **Persons Responsible:** D. Lissauer , J. Sondericker (Eng.)
 - **Institutions:** BNL
 - **Responsibility:** Refrigerator, Dewar, Quality Meters, Control System
-
- **Contract Air Liquide for**
 - Refrigerator (located on the surface)**
 - Nitrogen Dewar (located in the pit)**
 - compressor to be delivered to CERN next week
 - Valve boxes at CERN
 - Test nitrogen circulation system in July
 - **Quality Meter**
 - Measures N₂ gas/liquid ratio
 - provides feedback to temperature control
 - Production at BNL shops, shipped 6 (13 total)
 - **Control system being developed at BNL**
 - for functional analysis and programing for N₂ control.



Quality Meters

**Quality meter ready
for shipment to
ATLAS.**



**Designed at BNL and
built on site.**

**Mechanics and
associated controls.**

**Used to control the
flow of N_2 for
Cryostats cooling.**

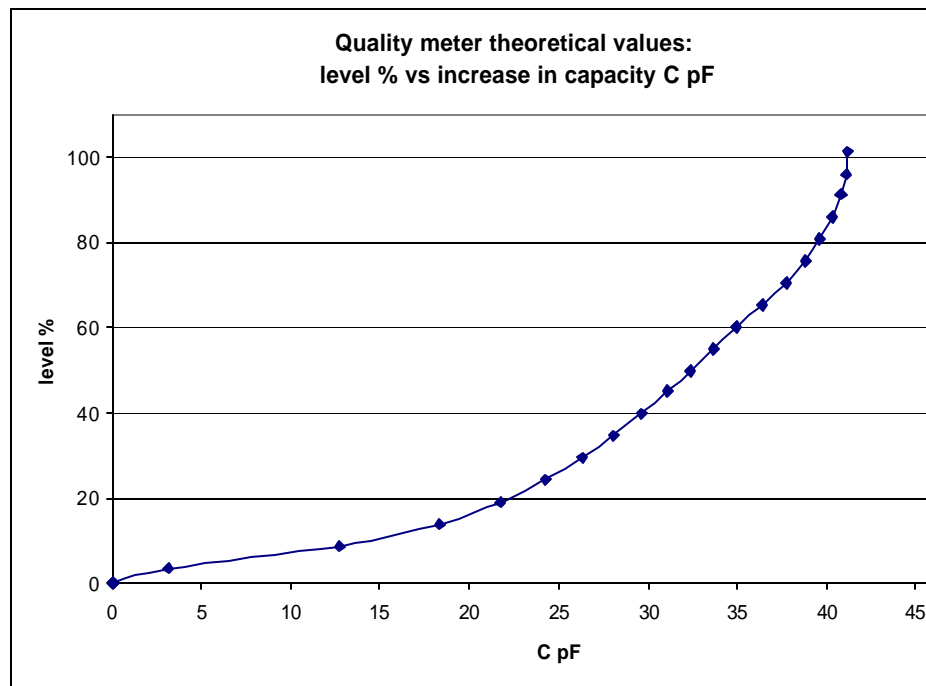
(Barrel & Endcaps)

**Quantity of liquid is detected by
measuring the capacitance of the
offset tube and the outer wall.**





Quality Meter Testing



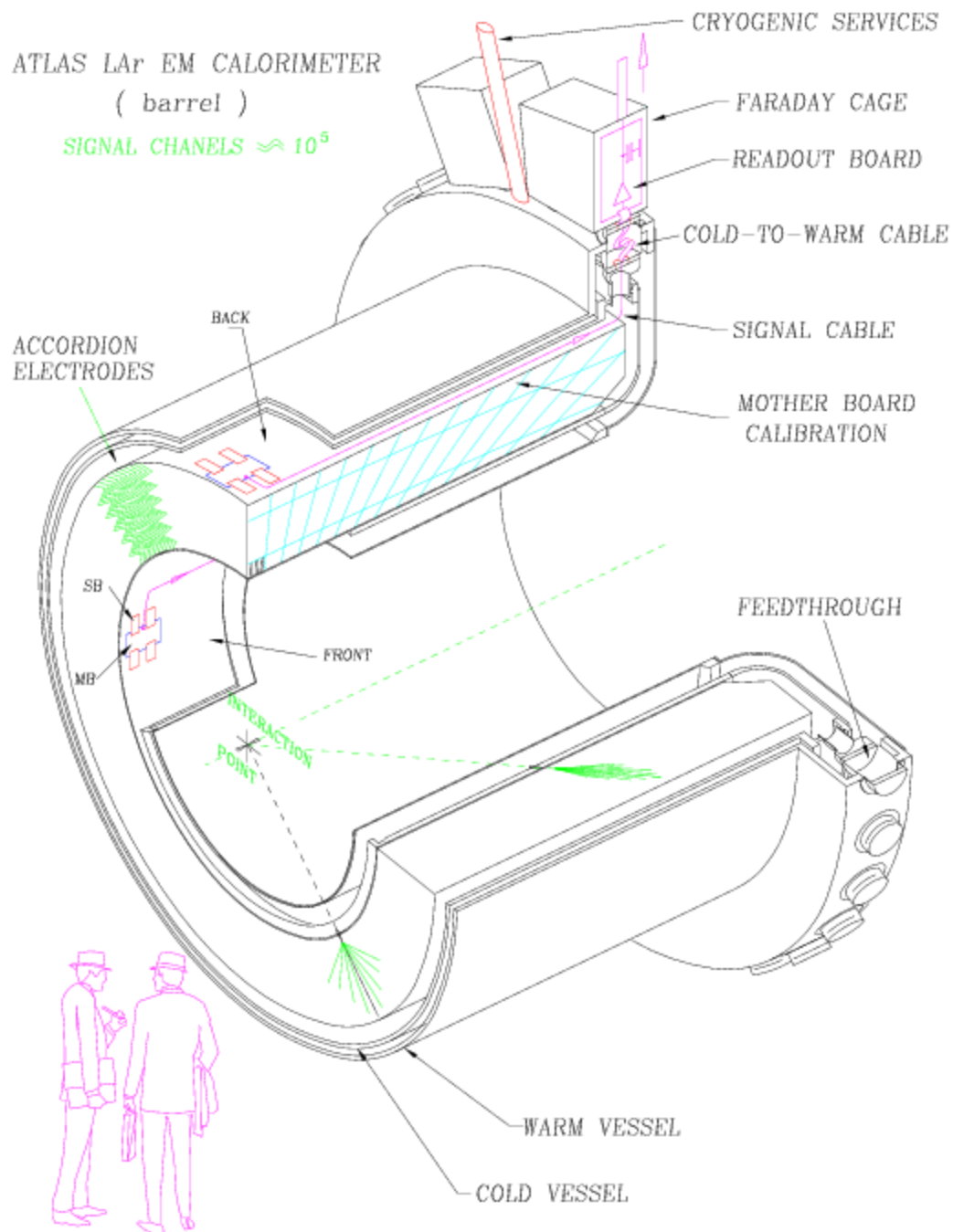
Y. Farah putting the finishing touches to the Capacitance to current conversion boards which read out the Q Meter signals. All are now complete, thoroughly checked out and calibrated.



Barrel EM Calorimeter

ATLAS LAr EM CALORIMETER
(barrel)

SIGNAL CHANNELS $\approx 10^5$





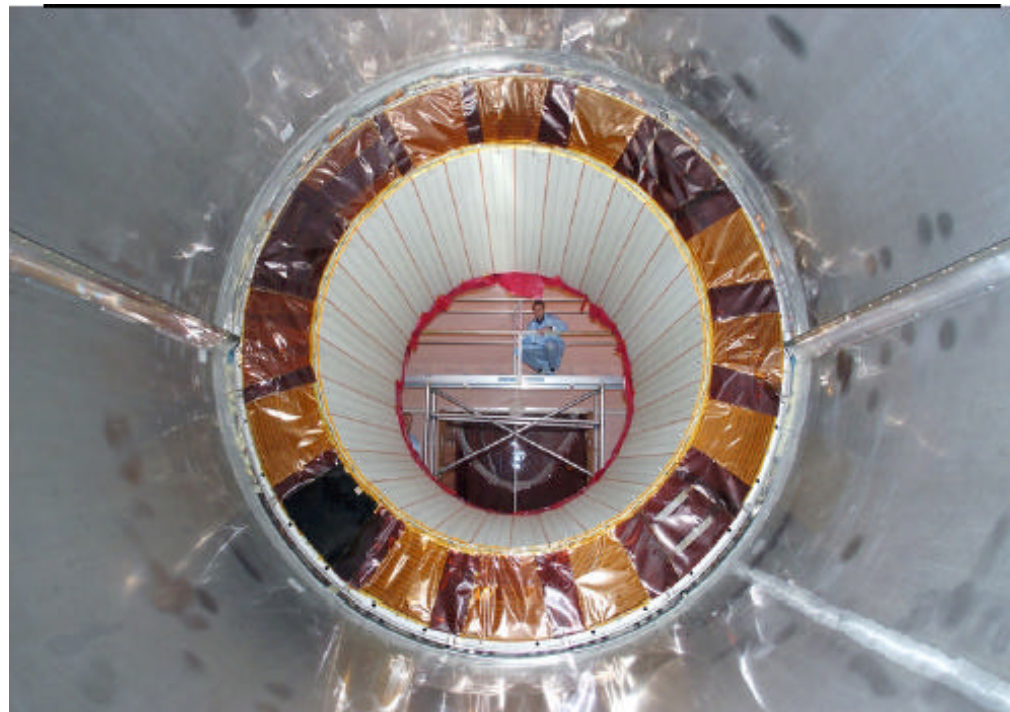
LAr Readout

- **Electrodes**
- **Motherboards and calibration**
- **Preamps**
- **System crate: on detector electronics**
 - Warm cables**
 - Base-plane – analog trigger sums.**
 - Pedestal and Crate**
 - Cooling system**
 - Rad-hard power supply**
- **Integration of front-end electronics**



EM Barrel Modules

- Responsible for design of large electrodes.
- contribution to the EM barrel electrode production.
- Electrode production completed.
- **First half of the EM barrel has been inserted into the cryostat.**
- **Second half to be completed by Sept 03**

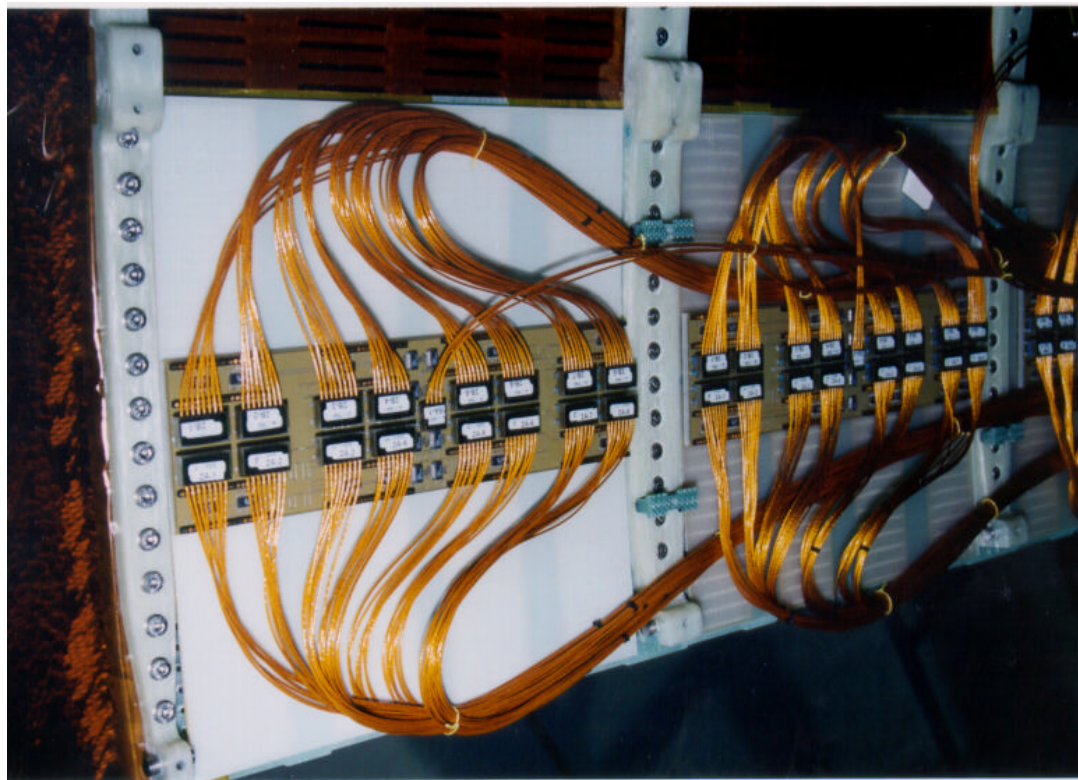


EM barrel inside cryostat
viewed from interaction point



Mother Boards

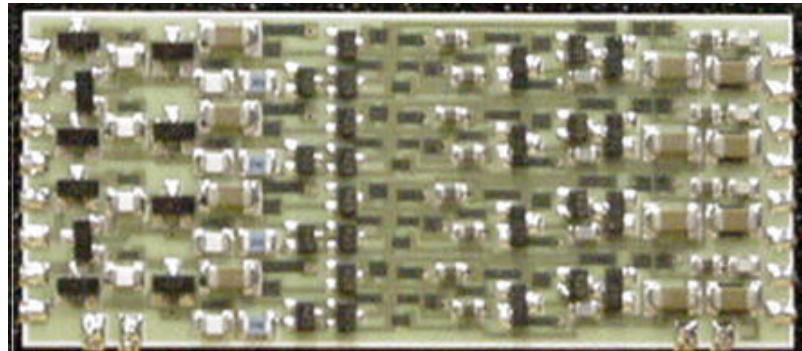
- **Persons responsible:** S. Rajagopalan, S. Rescia (eng.)
- **Institutions:** BNL
- **Responsibility:** All boards mounted on EM barrel calorimeter
- **Low crosstalk, high quality control**
- **Many different types of boards**
 - ◆ Summing Boards,
 - ◆ Mother boards,
 - ◆ HV boards,
 - ◆ Alignment/Cover Boards,
 - ◆ Protection Networks
 - ◆ TOTAL of 9380 boards
- **Production:**
 - ◆ Full test facility at BNL.
 - ◆ Started in Jan '00
 - ◆ **Completed in Oct '02**
 - ◆ **All shipped to CERN**





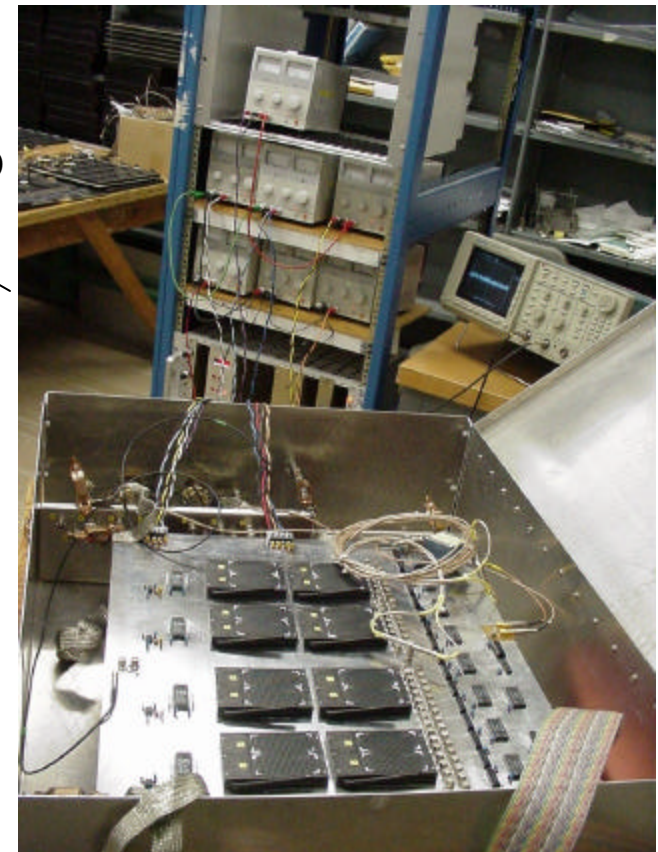
Preamps

- **Persons Responsible:** H. Ma, J. Kierstead (Eng.)
- **Institution:** BNL
- **Responsibility:** 120k channels of Preamps ($\frac{1}{2}$ LAr Calorimeter)
Participate in installation
- **Designed by BNL and Milano**
 - Low noise, high dynamic range
- **3 types of hybrids,**
 - 4 channels/hybrid, 30,000 total
- **Automated tests at BNL**
- **Preamps production started Feb 2001,**
- **Completed in Sept 2002,**
Ready to be installed in Front-end Boards.



hybrid

Test setup





Power Supply and Crate Assembly

- **Persons Responsible:** H. Takai, J. Kierstead (Eng.)
- **Institutions:** BNL, Nevis, Pittsburgh
- **Responsibility:** All Barrel and EC electronics crates
- **From feedthrough to electronics**
 - ◆ Warm cables, Pedestal and Base-planes
 - Production complete, Installed on barrel and one endcap
 - ◆ System Crates.
 - Production and assembly complete at BNL.
- **Critical component: LV Power Supplies**
 - ◆ Each 3.2 kW power
 - ◆ Radiation tests completed on components
 - ◆ Gamma, proton, and neutron radiation with less than 1% variation observed
 - ◆ Production prototype to be finished by Aug 2003
- **Cooling plates for PS and electronic modules**
 - ◆ Prototype stage, production to follow, assembly at BNL.



Mockup



BNL system Test
setup

CERN fullsize
Mockup





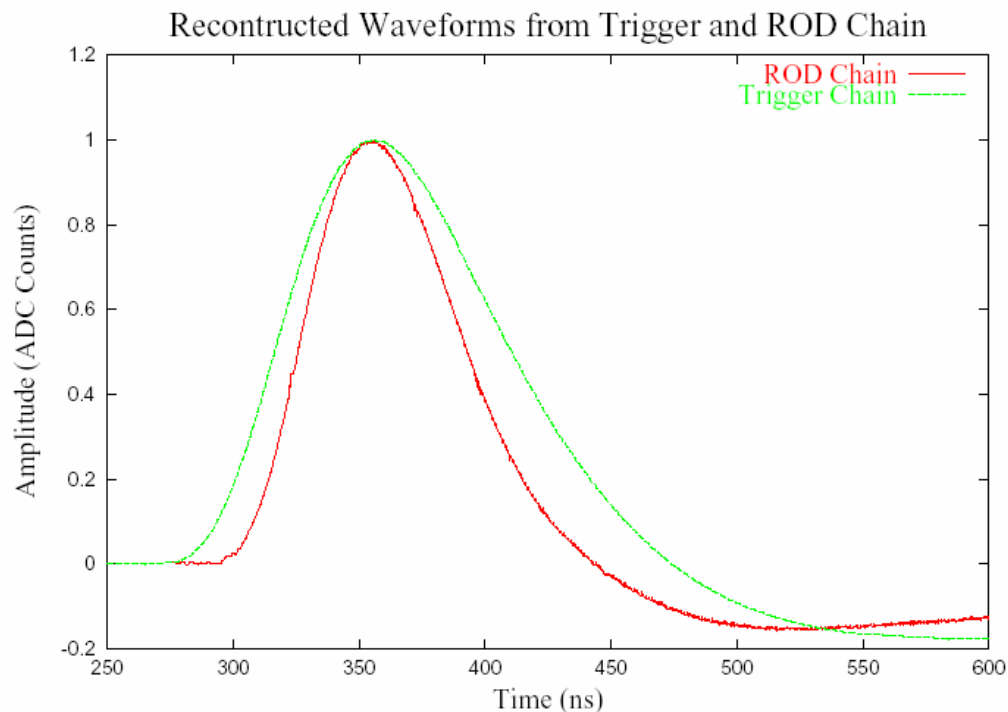
FrontEnd Crate System Test

- **Person responsible:** F. Lanni, H. Chen; S. Rescia, D. Makowiecki (Eng.)
- **Institutions:** BNL
- **Responsibility:** Full front-end electronics system integration
- F. Lanni is the LAr FrontEnd Electronics Coordinator
- FEC system test system at BNL:
 - Unique in ATLAS for LAr Calorimeter
 - Integration of power supply, cooling, ROD, DAQ, Analysis and People
 - Test for dynamic range, linearity, coherent noise, crosstalk.
 - Preparation for FEB production tests.
- System validation of FEC for All subsystems
 - ◆ EM-Barrel, EM-Endcap, Hadron Cal, Forward CAL
 - ◆ Prove system performance
 - ◆ Debug installation procedures
 - ◆ Identify possible critical points.



Recent FEC Test Activities

- Many collaborators have come to test components:
 - ◆ Annecy, Orsay, Saclay, Paris VI, Pittsburgh, Stony Brook, Nevis
- Calibration board has been installed and tested in the FEC setup
- Trigger Tower Builder has been installed and tested
- Online software integration
- ...



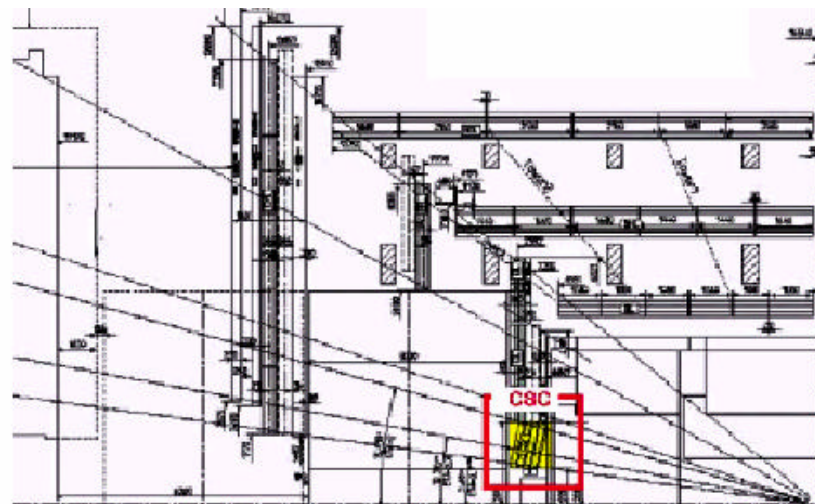
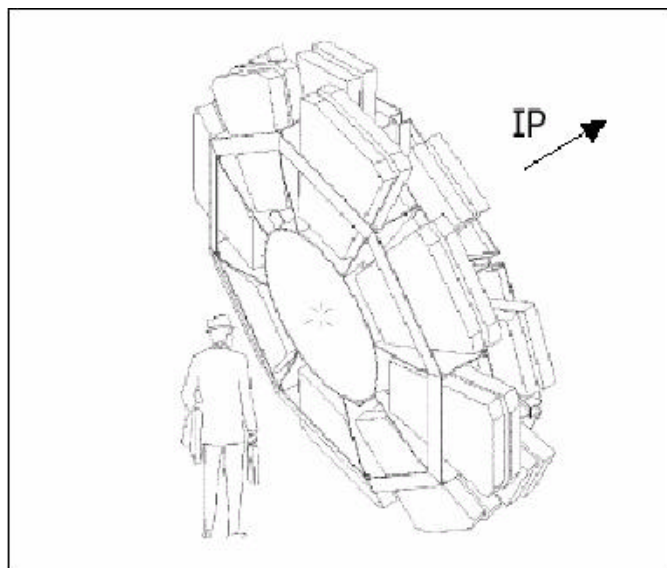


LAr Installation and Commissioning

- Our effort will shift from detector production to installation and commissioning.
- Cryogenics:
 - ◆ installation and commissioning in '04 and '05
- Barrel Cryostat:
 - ◆ Solenoid magnet installation end of '03-'04
 - ◆ Cold test in '04
 - ◆ Installation in pit in '05
- Electronics:
 - ◆ Frontend crates (modules+cooling) in '04-'05
 - ◆ Electronics installation in pit in '05-'06

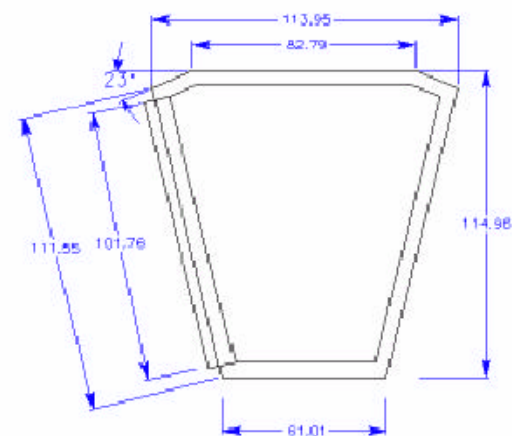
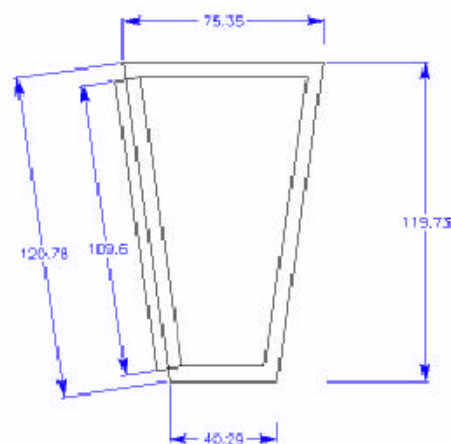


Cathode Strip Chambers: Precision Forward Muon System



Small

Large



32 four-layer chambers

$2.0 < |\eta| < 2.7$

$|Z| \sim 7\text{m}, 1 < r < 2\text{ m}$

4 gas gaps per chamber

31,000 channels



Cathode Strip Chamber

- **Person responsible:** V. Polychronakos, P. O'Connor, T. Muller (Eng.)
- **Institutions:** BNL
- **US Responsibility:** Design and construction of 32 CSCs
Installation
- Precision chamber in high rate environment
 - ◆ Determine muon position by interpolating the charge on 3 to 5 adjacent strips
 - ◆ Precision (x-) strip pitch $\sim 5.6\text{mm}$
 - ◆ Measure charge with $S/N=150:1$ to get $\sigma=60\mu\text{m}$
 - ◆ Second set of y-strip measure transverse coordinate to $\sim 1\text{cm}$
 - ◆ Requires accurate electronic intercalibration of adjacent channels
 - ◆ 2 chambers/octant, 32 total
 - ◆ 4 layers/chamber, upgradable to 8 layers
 - ◆ Operate in high rate environment
- Production and test facility at BNL

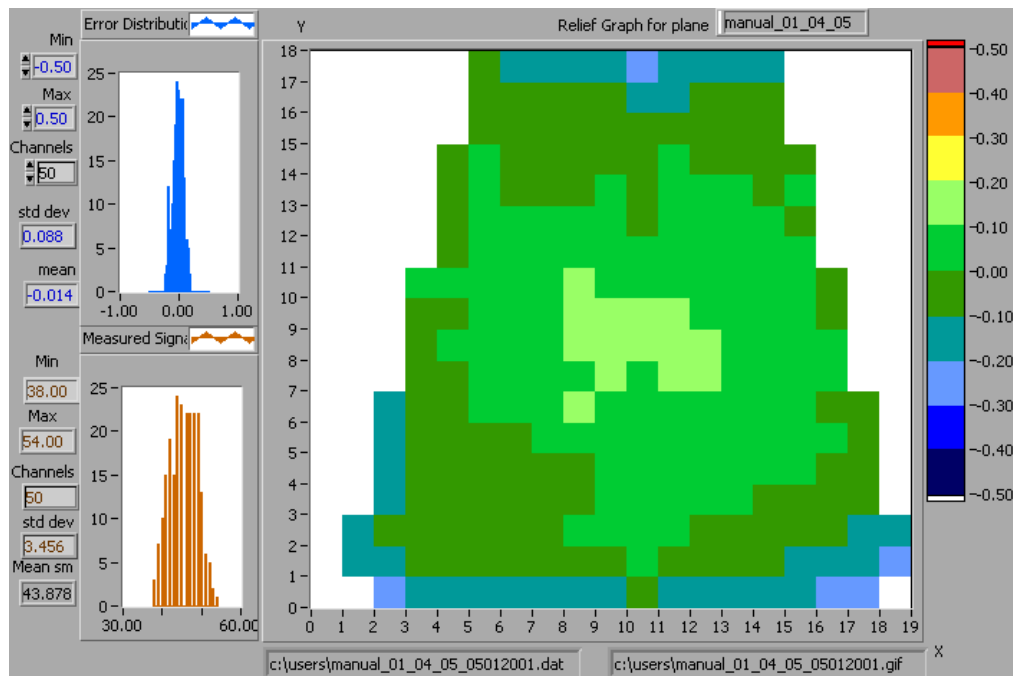


Anode Wire Plane Winding

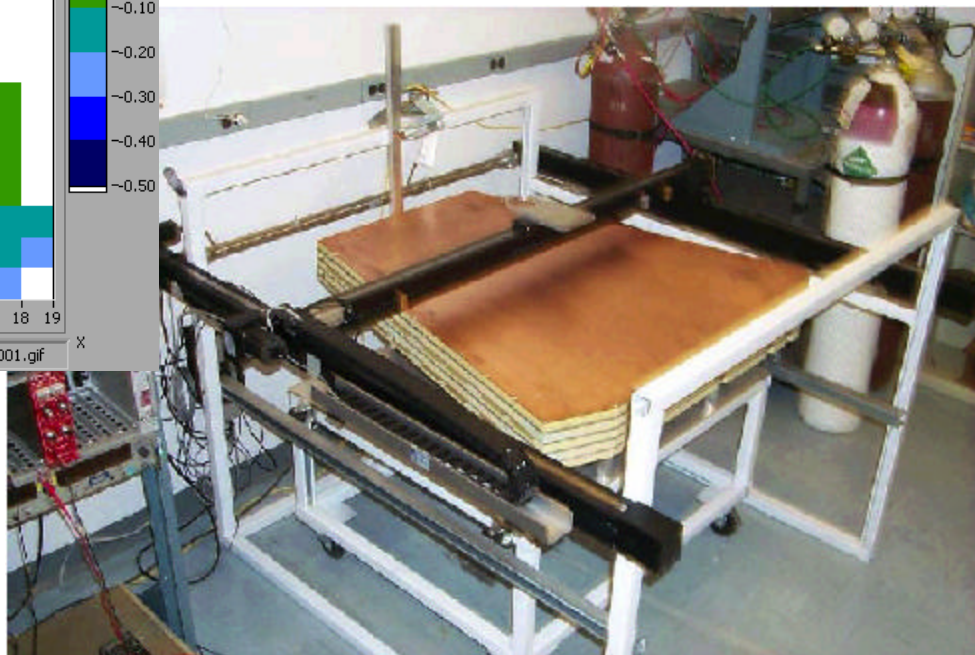




Gas Gain Measurements



**Chambers satisfy gain
uniformity spec**



100 mCi Americium Source mounted on a Gantry system maps gas gain with fine granularity with a simple current measurement



CSC Production

- **32 Chambers**
 - ◆ 16 CSC1 (corresponding to Large octants)
 - ◆ 16 CSC2 (corresponding to Small octants)
- **Assembly and test facility at BNL**
 - ◆ Wire Spacing and Tension Tests.
 - ◆ Panel Flatness Tests (mechanical and electrical).
 - ◆ Chamber Assembly and Electronic Flatness Tests.
 - ◆ Gas Gain measurements with radioactive source
- **Production Status**
 - ◆ CSC panel production is 50% complete.
 - ◆ 6 fully assembled CSC1 chambers.
 - ◆ Expect to finish production by end of '03, ahead of ATLAS installation schedule.



CSC Electronics

- **Person responsible:** V. Polychronakos, P. O'Connor
- **Institutions:** BNL, UC Irvine
- **Responsibility:** All on-chamber electronics
- **On chamber**
 - ◆ Amplifier/shaper (rad-hard Custom ASIC)
 - ◆ Analog memory and Digitization
- **Interconnect and services**
 - ◆ 1000 optical links
 - ◆ LV, HV distribution
 - ◆ Cooling, and Gas System
- **Readout Drivers developed by UC-Irvine**
- **Status:**
 - ◆ Production to start in Spring 2003



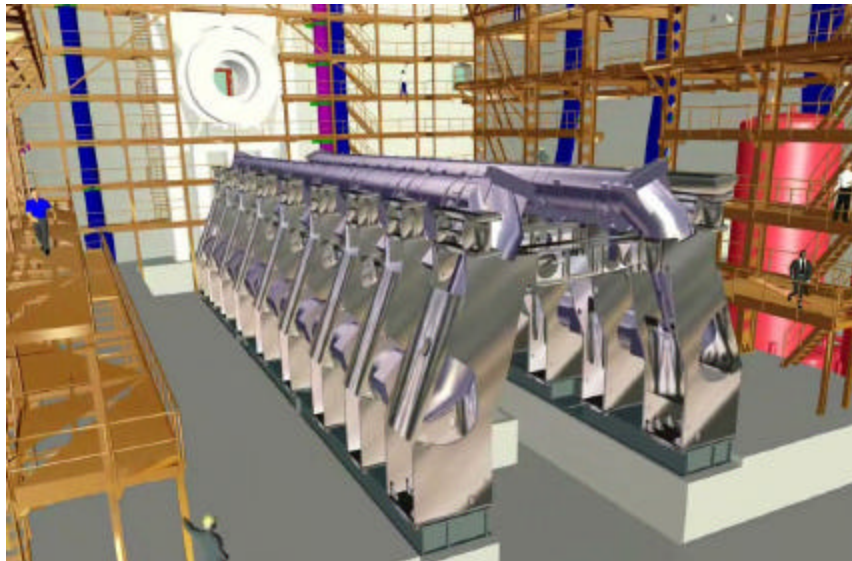
BNL in Technical Coordination

- D. Lissauer - Activity A (Project Office) Manager**
Member of ATLAS Technical Management Board
Coordinator for US ATLAS TC activities
(BNL,ANL, LBNL, Boston)
- S. Norton - Configuration Control**
- R. Ruggiaro- Services Routing**
- A. Gordeev - Access**

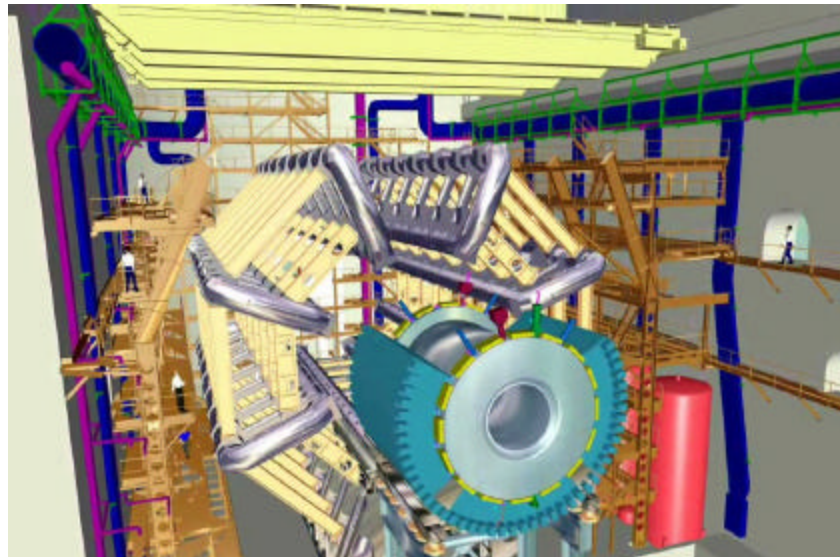


Installation Resource Planning

- **Installation studies included:**
 - ◆ Installation Sequence
 - ◆ Resources needed for installation, tooling, transport, manpower.
 - ◆ Specifications for placement in the Hall



February '04



August '04



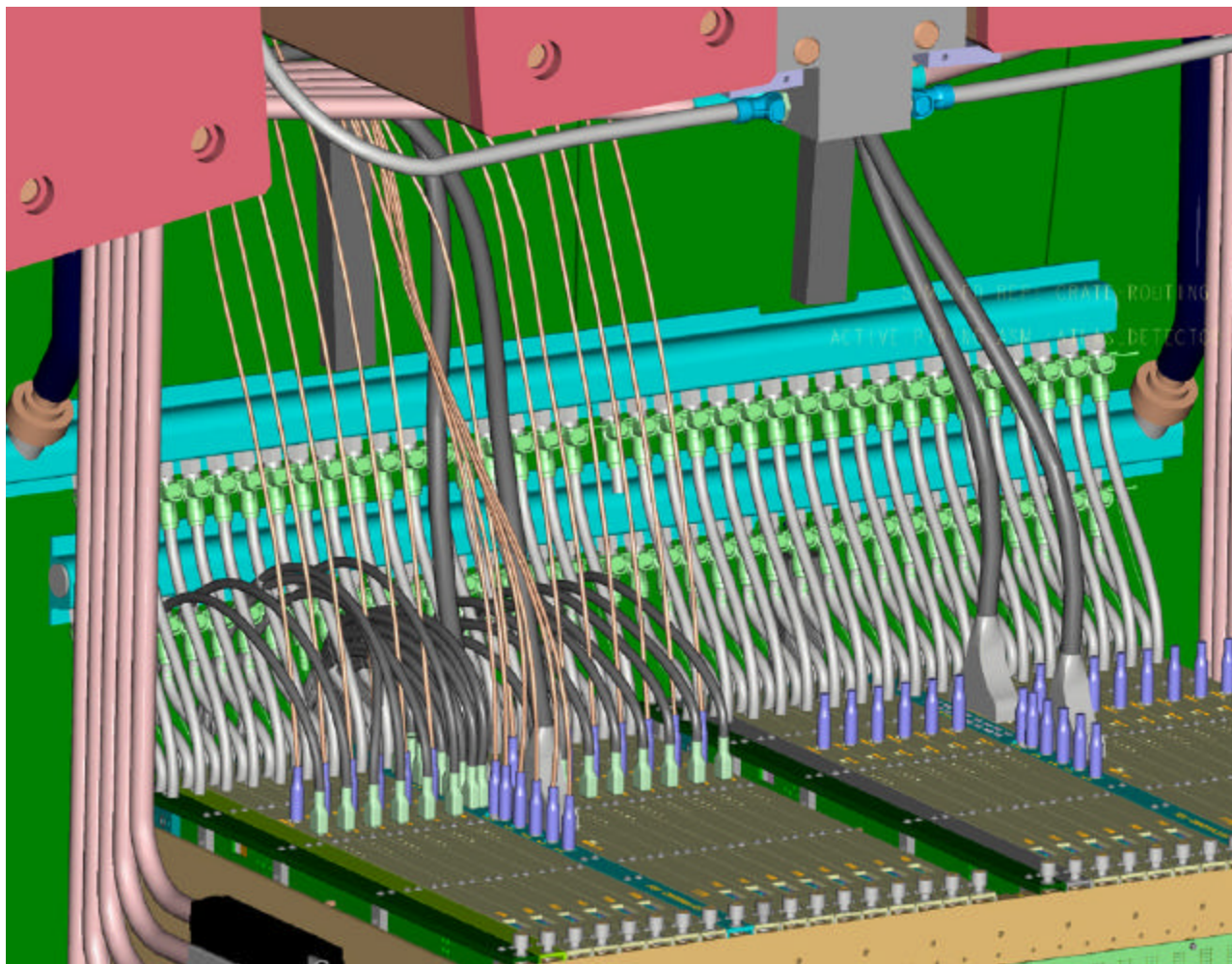
Examples of Studies

- **GAP Task Force:**
 - ◆ Increase the GAP between the Barrel and EC by ~40 mm
- **Z/R Envelopes:**
 - ◆ Increase all the Stay Clear Areas between moving systems.
- **Shielding:**
 - ◆ Major Changes in the shielding configuration.
- **New baseline for integrated Pixel/Beam pipe design.**
- **Access:**
 - ◆ Preliminary design for Barrel Calorimeter , EC Calorimeter Access.
- **Movement Studies:**
 - ◆ X, Z bracket design.
- **25 mm move in R for the toroids**
- **Single Beam pipe for VI and VA sections.**



Services and Routing

For example, detail routing of services and access to electronics





LHC upgrade

- Consider LHC Luminosity upgrade
 - ◆ SLHC : $L = 10^{35} \text{ /cm}^2 \text{ /s}^1$
 - ◆ Bunch crossing: 25ns \rightarrow 12.5ns
 - ◆ No. interactions/Crossing: 20 \rightarrow 100
 - ◆ Radiation: X10
 - ◆ Rates: X10
- We are studying detector upgrade for Inner Tracker and Calorimeter
 - ◆ Radiation tolerance
 - ◆ Rate capability
 - ◆ Pattern recognition capability



Inner Tracker

- ATLAS inner tracker will have to be rebuilt using higher granularity detectors for a harder radiation environment. Preserve the current pattern recognition, momentum resolution, b-tagging capability.
 - ◆ Radiation increase by ~ 10 .
 - ◆ To keep occupancy constant, granularity has to increase by a factor 10.
- ATLAS Inner Tracker:
 - ◆ Vertex detector ($r < \sim 20\text{cm}$)
aim for a pixels size factor $\sim 5-8$ smaller
($50 \times 400 \mu\text{m}^2 \rightarrow 50 \times 50 \mu\text{m}^2$)
 - ◆ Intermediate radius: $\sim 20 < r < \sim 60 \text{ cm}$
Aim for cell sizes 10 times smaller than conventional Si strip detectors.
 - ◆ Outer radius: $r > 60\text{cm}$
Replace TRT with large area Si detectors.



Inner Tracker R & D

**Tracking is challenging at SLHC,
Emphasis will be on optimizing the overall system**

- **Simulation:** Detector geometry, readout granularity.
- **Support Structure:** Integrated Support of the ID, “Massless”.
- **Cooling:** Thermal management of the system.
- **Si Detector:** Technology, Contact with industry.
- **Readout:** Technology, Power, Connections.
- **Module Layout:** Technology, Integration at the module level.
- **System Infrastructure:** Cabling, Multiplexing.
- **Optical Links:** Power consideration, multiplexing, Rad hard.
- **Power Supplies:** Location, distribution, Cabling.
- **Radiation Hardness:** Radiation hardness of ALL components.
- **System Tests:** Validation of the performance at the system level.



Summary

- **ATLAS detector construction at BNL is well underway, and on schedule**
 - ◆ Most LAr Calorimeter components are completed.
 - ◆ CSC construction will finish by end of '03
- **Major effort in system integration**
 - ◆ LAr front-end crate system test
 - ◆ Installation and commissioning
- **Technical Coordination**
 - ◆ Playing a critical role in ATLAS Technical Coord.
- **LHC upgrade:**
 - ◆ Inner Tracker R & D